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Salt balance in substrate cultivated with 'Sunki' mandarin x 'Swingle' citrumelo hybrids

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A B S T R A C T

During initial plant development stage, an experiment was conducted to evaluate the balance of salts in the substrate used for the production of 10 hybrids from the cross between 'Sunki' mandarin (TSKC) and 'Swingle' citrumelo (CTSW), all with potential to be used as rootstock. 'Rangpur Santa Cruz' lime, 'Sunki Tropical' mandarin and the hybrid LVK ('Volkamer' lemon) x LCR ('Rangpur' lime) - 038 were included as controls, totaling 13 genotypes. Substrate samples were collected in the experiment conducted in a greenhouse at the Federal University of Campina Grande, Campus of Pombal, from December 2015 to June 2016. Two levels of irrigation water salinity were tested, using a 2 x 13 factorial scheme, with 4 replicates. The substrate was a mixture of vermiculite, pine bark and humus (1:1:1). For the salinity level of 3 dS m^{-1}, the substrate is less salinized when cultivated with the hybrids TSKC x CTSW - 044, TSKC x CTSW - 045, TSKC x CTSW - 048, TSKC x CTSW - 049 and 'Rangpur Santa Cruz' lime. On the other hand, highest salt concentration was obtained in the substrate cultivated with TSKC x CTSW - 042, TSKC x CTSW - 047, TSKC x CTSW - 048, TSKC x CTSW - 053, TSKC x CTSW - 055 and TSKC x CTSW - 057.

Palavras-chave:
Citrus spp.
porta-enxerto
tolerância
salinidade

Balanço de sais em substrato de cultivo de híbridos de tangerineira 'Sunki' com citrumelo 'Swingle'

R E S U M O

Em fase inicial de desenvolvimento da planta, objetivou-se avaliar o balanço de sais no substrato de cultivo de 10 híbridos do cruzamento tangerineira 'Sunki' comum (TSKC) x citrumelo 'Swingle' (CTSW), todos com potencial de uso como porta-enxertos. Como testemunhas incluiu-se o limoeiro 'Cravo Santa Cruz', a tangerineira 'Sunki Tropical' e o híbrido LVK (limoeiro 'Volkameriano') x LCR (limoeiro 'Cravo') - 038, somando um total de 13 genótipos avaliados. Foram coletadas amostras do substrato em experimento desenvolvido em ambiente protegido da Universidade Federal de Campina Grande, Pombal, PB, de dezembro de 2015 a junho de 2016. Foram testados dois níveis de salinidade da água de irrigação (0,3 e 3 dS m^{-1}), em esquema fatorial 2 x 13, com 4 repetições, usando-se, como substrato, a casca de pinus, o húmus e a vermiculita na proporção 1:1:1. Considerando água de irrigação com nível de salinidade 3 dS m^{-1}, o substrato mostra-se menos salinizado em relação aos híbridos TSKC x CTSW - 044, TSKC x CTSW - 045, TSKC x CTSW - 048 e TSKC x CTSW - 049, assim como para o limoeiro 'Cravo Santa Cruz'. Por outro lado, a maior concentração de sais foi obtida no substrato em que são cultivados TSKC x CTSW - 042, TSKC x CTSW - 047, TSKC x CTSW - 041, TSKC x CTSW - 053, TSKC x CTSW - 055 e TSKC x CTSW - 057.

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Introduction

Salinity of soil and water is among the main problems in agriculture leading to reduction in crop yield (Gheyi et al., 2016). Despite being a global problem, salinity is more evident in arid and semi-arid regions, such as Northeast Brazil, for being characterized by low and irregular rainfall levels (Medeiros et al., 2003).

In addition, the predominance of waters with high levels of electrical conductivity in these regions should also be considered, reflecting in increased risk of salinization, if adequate management practices of plant, soil and water are not adopted (Araújo Neto et al., 2014; Dalastra et al., 2014).

The effects of salinity on agricultural production encompass osmotic effects, reducing water absorption by plants (Willadino & Câmara, 2010), and ionic effects, which can cause phytotoxicity and nutritional imbalance. These effects culminate in reduction of growth and potential of plants considered as sensitive (Taiz et al., 2015), such as citrus, which have mean salinity threshold of 1.4 dS m^{-1} (Mass, 1993).

Nonetheless, according to the literature, the effects of salts on crops can vary depending on species, cultivar, phenological stage, and intensity and duration of the saline stress (Silva et al., 2012; Sousa et al., 2017). Thus, using salt-tolerant rootstocks can be an alternative to guarantee successful citrus production in Northeast Brazil.

Based on studies conducted with citrus in recent years (Fernandes et al., 2011; Hussain et al., 2012; Silva et al., 2012; Hussain et al., 2015; Sá et al., 2015; Brito et al., 2016; Barbosa et al., 2017; Sá et al., 2017) to obtain genetic materials with potential for tolerance to salinity, it becomes necessary to evaluate new crosses and hybrids, which can be done by studying parameters that can help interpret tolerance mechanisms.

In this context, this study aimed to evaluate the balance of salts in the substrate used for cultivation, under saline water application, of citrus rootstocks considered as tolerant and belonging to the progeny resulting from the cross between 'Sunki' mandarin and 'Swingle' citrumelo.

Material and Methods

The experiment was carried out from December 2015 to June 2016 in a protected environment (greenhouse) at the Center of Sciences and Agri-food Technology (CCTA) of the Federal University of Campina Grande (UFCG), Pombal-PB, Brazil (6º 47' 20" S, 37º 48' 01" W, altitude of 194 m). The local climate is classified as BSh (hot and dry semi-arid), with mean annual rainfall of 750 mm and mean annual evapotranspiration of 2000 mm.

Treatments were arranged in randomized blocks, in 2 x 13 factorial scheme, corresponding to two levels of irrigation water salinity (S1 = 0.3 dS m^{-1} and S2 = 3 dS m^{-1}), which were used to irrigate 13 genotypes of rootstocks, 10 of which from the progeny of the cross between 'Sunki' mandarin and 'Swingle' citrumelo, namely TSKC x CTSW - 041, TSKC x CTSW - 042, TSKC x CTSW - 044, TSKC x CTSW - 045, TSKC x CTSW - 047, TSKC x CTSW - 048, TSKC x CTSW – 049, TSKC x CTSW - 053, TSKC x CTSW – 055 and TSKC x CTSW - 057. 'Rangpur Santa Cruz' lime (*C. limonia* Osbeck) (LCRSTC), 'Sunki Tropical' mandarin ('Sunki Tropical') and the hybrid between Volkamer lemon (*C. volkameriana* V. Ten. & Pasq.) (LVK) and 'Cravo' lemon (LCR) - 038 (LVK x LCR - 038) were included as control, for being salt-tolerant according to Brito (2010) and Barbosa et al. (2017).

All factors combined led to 26 treatments (2 salinity levels x 13 genotypes), repeated in 4 blocks, and each plot consisted of 1 plant, totaling 104 plots.

Seedlings were initially prepared in a protected environment at Embrapa Cassava and Fruits, considering all criteria for the initial production of rootstocks, such as the use of seeds from reputable companies, pest control and selection of nucellar plants.

At 75 days after sowing (DAS), the seedlings were transferred to 2000-mL black polyethylene bags and taken to the protected environment of the CCTA/UFCG, where the experiment was conducted. During growth period in the protected environment at Embrapa until the 90 DAS, the seedlings received public-supply water with low electrical conductivity (ECw = 0.3 dS m^{-1}).

At 90 DAS, solutions with different salinity levels began to be applied and irrigation depths were daily determined based on the water balance, obtained by drainage lysimetry, adding a leaching fraction (LF) of 0.20. In this process, the volume applied per bag (Va) was obtained by difference between the total volume applied in the previous night (Vta) and the volume drained (Vd) in the next morning, applying the leaching fraction, as indicated in Eq. 1 for each treatment.

$$\mathrm{Va} = \frac{\mathrm{Vta} - \mathrm{Vd}}{(1 - \mathrm{LF})}(\mathrm{mL}) \qquad (1)$$

Drained water was collected through a hose attached to the bottom of each bag and connected to a container, to measure the drained volume.

Nutritional management and all cautions with respect to weed control, and prevention and control of pests followed the recommendations for citrus seedling production proposed by Mattos Júnior et al. (2005).

Irrigation water of 3.0 dS m^{-1} was prepared in such a way to obtain an equivalent proportion of 7:2:1, of Na:Ca:Mg, respectively, using NaCl, $CaCl_2.2H_2O$ and $MgCl_2.6H_2O$ salts. This ratio corresponds to the ions present in most water sources used for irrigation in small properties of Northeast Brazil (Audry & Suassuna, 1995; Medeiros et al., 2003).

To prepare the solution with the desired electrical conductivity (ECw), the salts were added to the public-supply water, which had ECw of 0.3 dS m^{-1}, corresponding to the first salinity level studied. After preparation, the solutions were stored in 60 L plastic containers, one for each ECw level, properly protected to avoid evaporation and contamination with materials that could compromise their quality. Every two days, electrical conductivity was measured in the solutions using a portable conductivity meter, with value automatically corrected to 25 ºC, and its value was adjusted when necessary.

When the rootstocks had adequate diameter for grafting, about 0.5 to 0.7 cm, which occurred at 210 DAS, plants were cut close to the soil and roots were collected. The material (shoots and roots) was packed and dried in a forced-air oven for 72 h to obtain the dry matter or total dry phytomass (TDP), measured with an analytical scale, and the data were expressed in grams per plant.

Then, the substrates filling the bags were collected, dried, sieved, stored and labeled in plastic bags for analyses at the Laboratory of Soil and Plant Nutrition of the CCTA/UFCG, where the ions Ca^{+2}, Mg^{+2}, Na^{+} and K^{+}, soluble Cl^{-} and ECw were determined using the methodologies described in EMBRAPA (1997).

The obtained data were subjected to analysis of variance (ANOVA) by F test. In the cases of significance for the factor genotypes, means grouping test (Scott-Knott, $p < 0.05$) was applied for each water salinity level. To verify the differences between salinity levels in each genotype, the F test was conclusive (Ferreira, 2011).

Results and Discussion

Based on the balance of salts (Table 1), the use of saline water caused alterations in soil chemical characteristics, increasing the electrical conductivity of the saturation extract (ECse) and Ca^{+2} and Na^{+} concentrations as the salinity levels increased, which caused the substrate to be classified as saline when irrigated with 3 dS m^{-1} water, resulting in ECse higher than 4 dS m^{-1} in all containers. Lowest ECse values occurred in the substrate cultivated with the genotypes TSKC x CTSW - 044, TSKC x CTSW - 045, TSKC x CTSW - 048, TSKC x CTSW - 049 and LCRSTC, irrigated with high-salinity water. The lowest ECse values also coincided with the lowest Na contents in the substrate cultivated with first two hybrids.

Such increase in the concentration of ions was due to the use of Na, Ca and Mg salts to prepare the solution with the desired ionic concentration corresponding to the second salinity level (3 dS m^{-1}). These results corroborate those obtained by Brito et al. (2015), studying salt balance in the substrate and growth of 'Tahiti' acid lime grafted with 'Sunki' mandarin hybrids, under saline stress. These authors observed that the increase of salt concentration in the irrigation water led to linear increase in the concentration of ions in the substrate.

Variation of ionic concentration in the substrates, due to the hybrids cultivated in it, can be interpreted as a quantitative difference in the nutritional demand between the genetic materials, i.e., the absorbed contents of nutrients usually vary between genotypes, as mentioned by Epstein & Bloom (2006). In the literature on plant physiology, there are references to the selective permeability of the plasma membrane, adjusting the cell to the incorporation of ions according to plant needs, which vary depending on genetic constitution, development stage and conditions of soil and climate (Meer et al., 2008; Taiz et al., 2015). In addition, plants showed different growths, as can be observed in Table 2, based on the total dry phytomass.

For Mg^{+2} concentrations in the substrate solution (Table 3), there was no statistical difference between salinity levels for TSKC x CTSW-041, TSKC x CTSW - 042, TSKC x CTSW - 044, TSKC x CTSW - 045 and LVX x LCR - 038, although

Table 2. Test of means between citrus genotypes and between water salinity levels for total dry phytomass of citrus hybrids under water salinity

Genotypes	Total dry phytomass (g)	
	Irrigation water salinity (dS m^{-1})	
	0.3	3
TSKC x CTSW – 041	4.805 Ba	4.925 Aa
TSKC x CTSW – 042	4.417 Ca	4.307 Ba
TSKC x CTSW – 044	4.601 Ba	4.480 Ba
TSKC x CTSW – 045	4.715 Ba	3.882 Bb
TSKC x CTSW – 047	5.594 Aa	4.964 Aa
TSKC x CTSW – 048	4.893 Ba	4.353 Ba
TSKC x CTSW – 049	4.244 Ca	4.778 Aa
TSKC x CTSW – 053	4.695 Ba	5.027 Aa
TSKC x CTSW – 055	6.094 Aa	5.253 Ab
TSKC x CTSW – 057	5.688 Aa	4.838 Ab
'Rangpur Santa Cruz' lime	4.209 Ca	4.199 Ba
LVK x LCR-038	5.639 Aa	4.467 Bb
'Sunki Tropical' mandarin	4.044 Ca	4.780 Aa

Different uppercase letters indicate significant difference between hybrids by Scott-Knott test ($p < 0.05$) at a same salinity level, whereas different lowercase letters indicate significant difference between salinity levels by F test ($p < 0.05$) for a same genotype; TSKC - 'Sunki' mandarin [*Citrus sunki* (Hayata) hort. ex Tanaka]; CTSW - Swingle citrumelo [*C. paradisi* Macfad. x *Poncirus trifoliata* (L.) Raf.]; LVK - Volkamer lemon (*C. volkameriana* V. Ten. & Pasq.); LCR - 'Rangpur' lime (*C. limonia* Osbeck); LCRSTC - 'Rangpur Santa Cruz' lime

Table 1. Test of means between genotypes and water salinity levels relative to electrical conductivity (ECse), and contents of calcium (Ca^{+}) and sodium (Na^{+}) in the substrate cultivated with citrus hybrids under water salinity

Genotypes	ECse (ds m^{-1})		Ca^{+2} (mmol$_c$ dm^{-3})		Na^{+}(mmol$_c$ dm^{-3})	
	Irrigation water salinity (dS m^{-1})					
	0.3	3	0.3	3	0.3	3
TSKC x CTSW – 041	2.236 Ab	6.655 Aa	2.442 Cb	3.539 Ca	11.957 Ab	42.223 Aa
TSKC x CTSW – 042	1.295 Ab	6.400 Aa	1.951 Cb	3.774 Ba	8.994 Ab	43.528 Aa
TSKC x CTSW – 044	1.328 Ab	4.793 Ba	2.062 Cb	3.143 Ca	7.493 Ab	37.939 Ba
TSKC x CTSW – 045	1.550 Ab	5.632 Ba	2.316 Cb	3.288 Ca	9.277 Ab	37.644 Ba
TSKC x CTSW – 047	1.894 Ab	6.992 Aa	2.292 Cb	3.990 Ca	11.449 Ab	45.548 Aa
TSKC x CTSW – 048	1.141 Ab	5.166 Ba	2.127 Cb	3.241 Ca	8.971 Ab	40.835 Aa
TSKC x CTSW – 049	1.535 Ab	4.740 Ba	2.046 Cb	3.466 Ca	8.814 Ab	40.947 Aa
TSKC x CTSW – 053	0.985 Ab	6.655 Aa	1.818 Cb	3.259 Ca	8.890 Ab	43.402 Aa
TSKC x CTSW – 055	1.429 Ab	7.432 Aa	2.177 Cb	4.014 Ba	9.816 Ab	46.685 Aa
TSKC x CTSW – 057	2.377 Ab	6.872 Aa	2.959 Bb	3.954 Ba	11.592 Ab	45.271 Aa
'Rangpur Santa Cruz' lime	1.355 Ab	5.620 Ba	2.059 Ca	3.094 Ca	10.405 Ab	40.523 Aa
LVK x LCR – 038	2.923 Ab	6.065 Aa	3.593 Ab	3.437 Ca	13.405 Ab	43.680 Aa
'Sunki Tropical' mandarin	1.089 Ab	7.296 Aa	1.823 Cb	4.712 Aa	8.141 Ab	43.248 Aa

Different uppercase letters indicate significant difference between hybrids by Scott-Knott test ($p < 0.05$) at a same salinity level, whereas different lowercase letters indicate significant difference between salinity levels by F test ($p < 0.05$) for a same genotype; TSKC - 'Sunki' mandarin [*Citrus sunki* (Hayata) hort. ex Tanaka]; CTSW - 'Swingle' citrumelo [*C. paradisi* Macfad. x *Poncirus trifoliata* (L.) Raf.]; LVK - Volkamer lemon (*C. volkameriana* V. Ten. & Pasq.); LCR - 'Rangpur Santa Cruz' lime (*C. limonia* Osbeck); LCRSTC - 'Rangpur Santa Cruz' lime

$MgCl_2$ $6H_2O$ was added to the water, in the treatment with highest salinity (3 dS m^{-1}), which can be related to greater fixation to soil colloids and/or absorption by the genotypes, which had higher demand for the nutrient.

Regarding K contents in the extract, the increase in salinity raised the concentration in the substrate cultivated with the hybrids TSKC x CTSW- 042, TSKC x CTSW - 047, TSKC x CTSW - 048, TSKC x CTSW - 053, TSKC x CTSW- 055, TSKC x CTSW - 057, as well as 'Sunki Tropical' mandarin, which can be attributed to the reserves (stock) of this nutrient adsorbed to the colloids, besides the fertilizations.

Additionally, greater presence of Ca^{+2}, Mg^{+2} and Na^{+2} ions, applied through irrigation water, may have consequently increased the competition for the adsorption sites; Na^{+2}, Ca^{+2} and Mg^{+2} are attracted and bound to the colloids, releasing K^+ to the solution.

Garcia-Sánchez et al. (2006), cultivating 7-year-old plants of 'Clemenules' mandarin (*C. Clementina* hort. ex. Tanaka) grafted onto two rootstocks ['Cleopatra' mandarin (*C. reshni* hort. ex Tanaka) and 'Carrizo' citrange (*C. sinensis* x *P. trifoliata*)], irrigated with water containing NaCl at the concentrations of 3, 15 and 30 mM, for three years, observed increase of toxic ions (Cl^- and Na^+) and reduction of N, P and K contents in the leaves. Reduction of K^+ concentration in the plant due to increasing salinity is among the most studied effects, and the selective K^+ adsorption capacity associated with Na^{+2} exclusion is known as the tolerance mechanism of some plants to the saline stress (Willadino & Camara, 2010). In addition, elevated concentrations of Ca^{+2} and Mg^{+2} reduce K absorption by competitive inhibition, although low Ca^{+2} concentrations have synergetic effect on the nutrition of a few species (Faquin, 2005).

Chlorine is considered as an essential element to plants, but at the concentration of a micronutrient; at high concentrations, it is toxic. According to the data in Table 3, there was Cl accumulation in the substrate under irrigation with EC = 3.0 dS m^{-1}. Nonetheless, even under such conditions and although chlorine is the most harmful element to citrus species, when at high contents (Hussain et al., 2012; Syvertsen & Garcia-Sanchez, 2014; Brito et al., 2015), plants maintained their growth.

As already mentioned previously, besides reducing ECse and Na^+ content in the substrate cultivated with some genotypes, more evident in TSKC x CTSW - 044 and TSKC x CTSW - 045, in these hybrids and also in TSKC x CTSW - 048, chlorine contents were lower when plants were irrigated with high-salinity water.

To survive under these conditions, plants may have used mechanisms of tolerance to the stressful condition because, according to Gheyi et al. (2016), Cl^--sensitive plants may exhibit symptoms of toxicity, which consist of burn on tip of the leaves, reaching the edges in advanced stages; in general, premature leaf abscission occurs, and these symptoms appear when chloride concentration reaches 0.3 to 1.0%, based on leaf dry matter. Also according to these authors, the maximum chloride level (in $mmol_c$ dm^{-3}) in the saturation extract for Cleopatra mandarin, bitter orange and sweet orange cannot exceed 25, 15 and 10 $mmol_c$ dm^{-3}, respectively, which are lower than the values observed in the present study, as the contents of Na^+ ions.

In the same context, Ayers & Westcot (1999) cite 10 $mmol_c$ dm^{-3} as maximum limit allowed of chloride for citrumelo, which would make the salinity observed in the present study even more harmful, considering the values found in the substrate cultivated with the 'Sunki' x 'Swingle' hybrids (TSKC x CTSW), denoting the tolerance capacity of these genotypes.

Complementing this discussion, phytomass data of the genotypes are presented in Table 2, showing differences between rootstocks at each level of water salinity. Even with the use of water containing low salt concentration (0.3 dS m^{-1}), it is noticeable the difference of vigor between the genotypes, particularly TSKC x CTSW - 047, LVK x LCR - 038, TSKC x CTSW - 055 and TSKC x CTSW - 057. These latter two were affected by salinity when plants were irrigated with saline water (3 dS m^{-1}), but even in this condition they remained in the group of higher phytomass.

Except for the two genotypes cited (TSKC x CTSW - 055 and TSKC x CTSW - 057), the rootstocks TSKC x CTSW - 045 and LVK x LCR – 038 were affected also by the highest salinity, because they remained in an inferior group of tolerance to saline stress.

Table 3. Test of means for potassium (K^+), magnesium (Mg^{+2}) and chloride (Cl^-) in the substrate cultivated with citrus hybrids subjected to water salinity

Genotypes	K^+ ($mmol_c$ dm^{-3})		Mg^{+2} ($mmol_c$ dm^{-3})		Cl^- ($mmol_c$ dm^{-3})	
	Irrigation water salinity (dS m^{-1})					
	0.3	3	0.3	3	0.3	3
TSKC x CTSW – 041	6.084 Aa	3.082 Ab	3.121 Aa	3.393 Aa	19.166 Ab	81.875 Ba
TSKC x CTSW – 042	1.840 Bb	4.701 Aa	2.629 Aa	2.990 Ba	12.500 Ab	82.500 Ba
TSKC x CTSW – 044	1.529 Ba	2.758 Aa	2.499 Ba	2.529 Ba	11.875 Ab	70.833 Ca
TSKC x CTSW – 045	2.136 Ba	3.066 Aa	2.317 Ba	2.548 Ba	14.375 Ab	64.375 Ca
TSKC x CTSW – 047	1.620 Bb	3.744 Aa	3.062 Ab	3.744 Aa	14.375 Ab	79.375 Ba
TSKC x CTSW – 048	0.808 Bb	3.231 Aa	2.115 Bb	3.009 Ba	10.416 Ab	70.833 Ca
TSKC x CTSW – 049	1.367 Ba	2.529 Aa	2.245 Bb	3.152 Ba	11.666 Ab	73.833 Ba
TSKC x CTSW – 053	1.168 Bb	3.136 Aa	2.167 Bb	3.472 Aa	13.125 Ab	83.125 Ba
TSKC x CTSW – 055	1.061 Bb	3.733 Aa	1.690 Bb	3.472 Aa	18.750 Ab	103.75 Aa
TSKC x CTSW – 057	2.098 Bb	4.846 Aa	2.856 Ab	3.533 Aa	15.000 Ab	85.625 Ba
'Rangpur Santa Cruz' lime	1.679 Ba	2.749 Aa	2.046 Bb	2.935 Ba	15.625 Ab	76.875 Ba
LVK x LCR – 038	2.156 Ba	2.803 Aa	3.234 Aa	3.007 Ba	15.000 Ab	78.125 Ba
Sunki 'Tropical' mandarin	1.448 Bb	4.077 Aa	2.401 Bb	4.016 Aa	12.812 Ab	81.250 Ba

Different uppercase letters indicate significant difference between hybrids by Scott-Knott test ($p < 0.05$) at a same salinity level, whereas different lowercase letters indicate significant difference between salinity levels by F test ($p < 0.05$) for a same genotype; TSKC - 'Sunki' mandarin [*Citrus sunki* (Hayata) hort. ex Tanaka]; CTSW - 'Swingle' citrumelo [*C. paradisi* Macfad. x *Poncirus trifoliata* (L.) Raf.]; LVK - 'Volkamer' lemon (*C. volkameriana* V. Ten. & Pasq.); LCR - 'Rangpur' lime (*C. limonia* Osbeck); LCRSTC - 'Rangpur Santa Cruz' lime

Among the genetic materials, TSKC x CTSW – 055 stands out in the group of genotypes with higher dry matter accumulation in the treatments of both lower and higher salinity, with EC of 7.43 dS m^{-1} in the saturation extract of the substrate where it was cultivated (Table 1) and chloride concentration of 103.75 $mmol_c$ dm^{-3} (Table 3). The EC value is much higher than that of salinity threshold for citrus plants, and chloride concentration exceeds the respective level of toxicity reported in the literature (Ayers & Westcot, 1999).

The highest ECw level did not affect the phytomass of most rootstocks, an evidence of their potential to be used under saline conditions, particularly TSKC x CTSW - 041, TSKC x CTSW - 047, TSKC x CTSW - 049, TSKC x CTSW - 053, as well as 'Sunki Tropical' mandarin, a difference attributed to the hybrid potential of each material (Fernandes et al., 2011; Barbosa et al., 2017).

Conclusions

1. Increasing water salinity modifies the absorption nutrient by the genotypes, which have different nutritional demands.
2. Salinization of the substrate irrigated with 3 dS m^{-1} water is lower when cultivated with the hybrids TSKC x CTSW - 044, TSKC x CTSW - 045, TSKC x CTSW - 048, TSKC x CTSW - 049, and 'Rangpur Santa Cruz' lime.
3. Higher concentration of salts in the water increases K^+ concentration in the substrate cultivated with the hybrids TSKC x CTSW - 042, TSKC x CTSW - 047, TSKC x CTSW - 048, TSKC x CTSW - 053, TSKC x CTSW - 055 and TSKC x CTSW – 057, indicating lower absorption of K^+.

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